Effects of Habitat and Location on Chipping Sparrow Song Characteristics

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Field work performed with Melissa Burns[2]

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Abstract: The acoustic adaptation hypothesis states that animal calls should adapt to their environment: birds singing in a closed forest should have lower frequency and slower rate than birds in open habitats in order for their songs to be heard best at far distances. To test the acoustic adaptation hypothesis in Chipping Sparrow song, we recorded and analyzed maximum frequency, minimum frequency, frequency range, and trill rate of Chipping Sparrows in two different habitat types. We found no statistically significant results, but all four song characteristics slightly opposed the acoustic adaptation hypothesis. Although Chipping Sparrows may not follow the predictions of the acoustic adaptation hypothesis, insignificant results should not be interpreted as rejecting the acoustic adaptation hypothesis in Chipping Sparrows as their interactions with neighboring Pine Warblers, our small sample size, closeness of sites, and little habitat differences could have altered our results.

Introduction

The acoustic adaptation hypothesis (hereafter the AAH), first proposed by Morton in 1975 and termed by Rothstein and Fleischer in 1987, states that animal calls, when intended to transmit on the order of territory ranges, should be in a form that is minimally altered by the environment (Brown and Handford 1996). As songs travel their signals both degrade (change) and attenuate (reduction in amplitude and intensity). The main form of degradation changes from reverberation to irregular amplitude fluctuations as the habitat changes. This causes different vocal characteristics to be optimal in different settings. Reverberation is common in closed habitats because sound reflects off tree trunks and canopy and can be minimized by avoiding repeated elements or trills (Brown and Handford 1996). Irregular amplitude fluctuations, which results from air pockets in open environments, are heard as fluctuation of intensities and should be counteracted by rapid repetition of elements or trills (Brown and Handford 1996). High frequency songs are attenuated more in closed environments than open environments (Morton 1975) so birds in closed habitat should have lower frequency songs. When both of these principles are applied to bird song characteristics in closed versus open environments, the AAH predicts that birds living in closed habitat should sing at a lower frequency and slower rate than birds living in open habitats (Morton 1975, Brown and Handford 1996).

Recent studies have shown mixed support for the AHH. Wiley’s (1991) survey of Eastern North American oscines found that of maximum, minimum and dominant frequencies, only maximum frequency was significantly lower in forest habitats while presence of repeated elements (trills) was significant. This contrasts with Boncoraglio and Saino's (2007) meta-analysis of all literature between 1975-2006, which found maximum, minimum, and dominant frequencies were all significant but that rate of repeated elements was not. Experiments analyzing variation in different populations of species have also had mixed support for the AAH (see Nicholls and Goldizen 2006 for support, and Hylton and Godard 2001 for rejection) , causing Boncoraglio and Saino (2007) to conclude that "habitat structure only weakly predicts the acoustical properties of bird songs."

The purpose of this study was to determine the effect of habitat on Chipping Sparrow (*Spizella passerina*) song and see if it follows the predictions of the AAH. Chipping Sparrows make a good study species for testing the AAH for three reasons: 1) they have a simple repetitive song so variance in it is quite easy to observe and quantify, 2) their songs have little genetic control (Liu and Kroodsma 2006) so environment should play a crucial factor in song determination, 3) they occupy both mixed forest and open habitats. Because of the different ways sound propagates, chipping sparrows in mixed forest habitats should have a lower frequency and a slower trill rate than those in open habitats.

Methods

Chipping Sparrow songs were recorded during their dawn chorus (0530 to 0630 EDT) from July 17, 2007 to July 31st 2007. Songs were recorded from two sites: 1) the University of Michigan Biological Station (UMBS) where the habitat varied from open fields to mixed forests, and 2) two cemeteries on Church Road, a few miles from UMBS, where the habitat was open field with scattered trees. Only dawn chorus songs were recorded because it was the only consistent singing by the Chipping Sparrow, and because it functions as a territorial song

(Kroodsma and Liu 2007). Territorial songs should follow one of the key assumptions of the AAH: it would benefit the chipping sparrow to be heard at long distances with minimal interference. Each site had between 5-8 birds recorded, each singing 5-12 songs. The habitat type, time and location of each bird were recorded. Three of the eight birds at the UMBS were classified as singing in open habitats, while all Church Road birds were designated as singing in open habitats.

A PMD660 Marantz Professional Solid State Recorder and a Sennheiser K6 microphone were used under the 48k mp3 mono mic input setting for the recordings. Song data was transferred to Raven: Interactive Song Analysis Software V1.2.1 (http://www.birds.cornell.edu/brp/raven/RavenFeatures.html) , where all usable songs (songs where the maximum and minimum frequency were clearly visible) from an individual were analyzed for maximum frequency, minimum frequency, frequency range, and trill rate (# of notes per second).

Because UMBS had both mixed forest and open field habitat types within it, data from the birds were analyzed in two ways: by habitat (mixed forest or open, N=5 and 8) and by location (UMBS or Church Road N=8 and 5.) Mean values were calculated for the four song characteristics of each bird and then after checking for normality, an Independent Samples T-test was run comparing the two categories of interest.

Results

Independent T-tests found maximum frequency, minimum frequency, frequency range, and trill rate were all slightly higher in birds found in mixed forests but not to the point of statistical significance (p values of 0.085, 0.308, 0.376, and 0196, respectively; Figs. 1-4)

Likewise when separating birds by location UMBS bird's songs were slightly higher in maximum frequency, minimum frequency, frequency range, and trill rate than Church Road bird's songs, but not to the point of statistical significance (p values of 0.197, 0.575, 0.382. and 0.691; Figs. 5- 8).

Anecdotal Results: Chipping Sparrows were observed in singing duels with pine warblers in the UMBS site (Anderson, personal communication.) While scouting for more mixed forest chipping sparrows near the UMBS site, several pine warblers responded agitatedly to chipping sparrow playback.

Discussion

It is not surprising that our results do not support the AAH as many studies don't agree with its findings. The different conclusions of which song characteristics should follow the AAH from many broad ranging studies such as Wiley (1991) and Boncoraglio and Saino (2007) suggest that the AAH is more a vague guideline than a biological rule. Reasons for birds not following the AAH have been suggested. Boncororaglio and Saino (2007) note that the AHH assumes a bird wishes to maximize song broadcast range and minimize degradation without taking into account the possible decrease in fitness of an individual due to energetic costs of singing and increased predation. Hylton and Godard (2001) suggest that populations in different habitats may show no difference in songs because of social song learning. The Chipping Sparrow is a social song learner (Liu and Kroodsma 2006; Liu and Kroodsma 1999) so this could be a reason why our study populations showed no difference.

There are also many examples of species where populations don't follow the AHH such as Indigo Buntings (Hyton and Godar 2001) and New World Doves (Tubaro and Mahler 1998). The Chipping Sparrow may be yet another species that's song is not optimized according to the hypothesis. One reason, besides those presented above, could be that the Chipping Sparrow is an edge species (Middleton 1998), and when found in mixed forests it is usually near some sort of opening causing no difference to be found between mixed forest and open field birds.

However failure to find differences in the populations should not be used as evidence that Chipping Sparrows do not follow the prediction of the AAH, as problems involving the presence of Pine Warblers, the sample size, the closeness of the two sites, and habitat differences arose during our study.

Around areas of the UMBS there were several observations of Pine Warblers responding to chipping sparrow songs. In the summer of 2006, Ted Anderson heard a pine warbler and a chipping sparrow calling back and forth to each other; in 2007 we observed pine warblers responding agitatedly to recorded chipping sparrow songs, acting very similarly to how they respond to playback of their own species. It could be possible that chipping sparrows are learning or modifying their songs from their pine warbler neighbors. This hypothesis however seems hard to support when viewed under circumstantial evidence. The chipping sparrows song functions primarily for territorial defense and mate attraction (Liu and Kroodsma 2007), resembling a song of another species seems very maladaptive for attracting mates and should result in a fitness decrease. These calls and response could suggest a form of interspecies territoriality between the two species however the birds seem to utilize very different resources. Although no studies of diet have been done on the UMBS population the chipping sparrow feeds primarily on seeds of grasses while occasionally eating small fruit (Middleton 1998), while the Pine Warbler feeds primarily on arthropods with seed supplementation during the winter (Rodewald et all 1999). Nests sites could be a potential dispute, but although Chipping Sparrows prefer conifers like pine trees they utilize a variety of nest sites (Middleton 1998). There seem to be very little clearly evident advantages for a Chipping Sparrow to sound like a Pine Warbler.

Although no songs of Pine Warblers from the UMBS were analyzed it appears that their songs are quite lower in frequency ranging from 2.5 to 5.7 kHz with a much faster trill rate of close to 20 notes per second (Rodewald et all 1999). The birds we recorded near the pine warblers, although statistically insignificant, were somewhat higher in frequency and faster in trill rate. Their songs were not distinctly different in characteristics than any of the other Chipping Sparrows, which we would expect to find if they were learning their songs from Pine Warblers, and it appears that although chipping sparrows do engage in duels with Pine Warblers they do not learn their songs from them. An experiment in the lab using Pine Warbler and Chipping Sparrow tutors could confirm this issue.

In the two weeks in the field for the study due to lateness of the season, technical difficulties with recording equipment, and bad weather we were only able to record usable songs for 13 Chipping Sparrows. There were many more birds heard and seen at each site than we were able to gather songs of. It is quite possible that differences do exist both based on habitat and between the two populations studied, but that our small sample size makes these differences impossible to detect.

Even if all the birds at each site were recorded, it is also possible that problems with our sites would still make the differences in habitat undetectable. It has been shown that most chipping sparrows learn their songs by imitating a nearby male in their first spring after migration to breeding areas (Liu and Kroodsma 2006; Liu and Kroodsma 1999). While at first this appeared beneficial to the study as birds would learn their songs directly from those that have already succeeded in their environment, it can also be problematic when two sites with differing habitats are close together. Little is known about chipping sparrow dispersal, so it is quite possible that a bird that learned its song in the UMBS's mixed forest could be nesting the short distance away in the Church Road site's open habitat the next year. In this case a bird's song would not be adapted to its habitat.

Aside from the geographic proximity of our sites, there were also problems with the habitat at the UMBS. The UMBS is mostly mixed forests, but there are also open areas such as fields, paths, parking areas, buildings, roads and both basketball and volleyball courts. This makes the forest canopy, although present in many areas and much more covered than the Church Road site, spotty at best. Although we analyzed the song characteristics by habitat as well as site in an attempt to counteract the UMBS's variation, these birds are in close proximity and interact with the mixed forest birds. A mixed forest bird at the UMBS could have learned or modified its song from an open habitat bird, and vice versa. The site is also next to Douglas Lake, where sound would carry much differently than in a mixed forest. The UMBS was not an ideal mixed forest habitat. When the patchiness of it is considered it could be that the song characteristics best suited for it are the same as, or very similar to, those of open fields.

Our results suggest that the Chipping Sparrow could be another bird species which does not follow the predictions of the AAH. However our small sample size and the presence of Pine Warblers, which may possibly be altering Chipping Sparrow songs, could have masked differences in the populations studied. It is also possible that our two sites do not have optimal song characteristics because of year to year chipping sparrow dispersal, or that the optimal song for each site is the same because of the problems with the UMBS habitat. In these cases other populations of Chipping Sparrows could possibly support the AAH.

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Figure Legend

Figure 1: A comparison of mean high frequency in chipping sparrow songs between forest and open habitat. T-test gave a p-value of 0.085.

Figure 2: A comparison of mean low frequency in chipping sparrow songs between forest and open habitat. T-test gave a p-value 0.308.

Figure 3: A comparison of mean frequency range in chipping sparrow songs between forest and open habitat. T-test gave a p-value of 0.376.

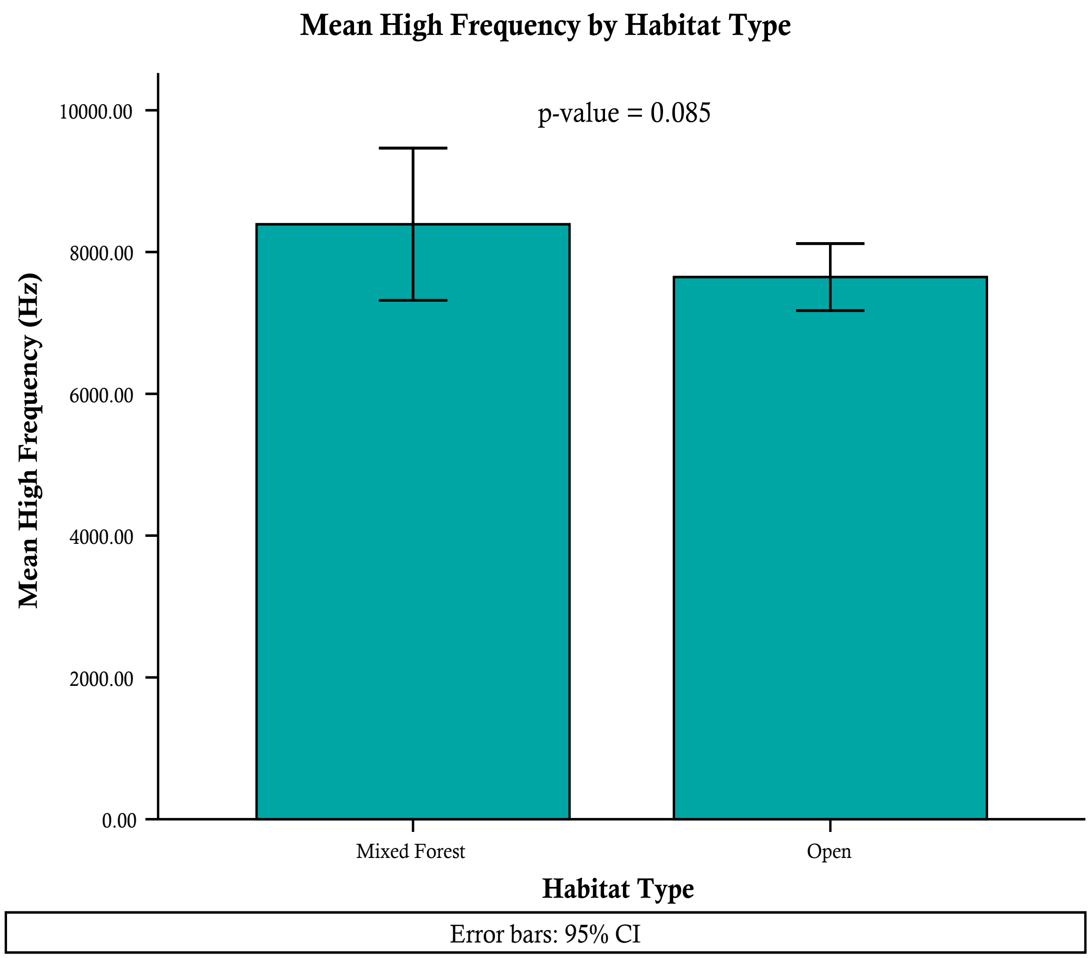
Figure 4: A comparison of mean trill rate in chipping sparrow songs between forest and open habitat. T-test gave a p-value of 0.196.

Figure 5: A comparison of mean high frequency in chipping sparrow songs between UMBS forest and Non-UMBS open habitats. T-test gave a p-value 0.197.

Figure 6: A comparison of mean low frequency in chipping sparrow songs between UMBS forest and Non-UMBS open habitats. T-test gave a p-value 0.575.

Figure 7: A comparison of mean frequency range in chipping sparrow songs between UMBS forest and Non-UMBS open habitats. T-test gave a p-value 0.382.

Figure 8: A comparison of trill rate in chipping sparrow songs between UMBS forest and Non-UMBS open habitats. T-test gave a p-value 0.691.


Mean High Frequency by Habitat Type
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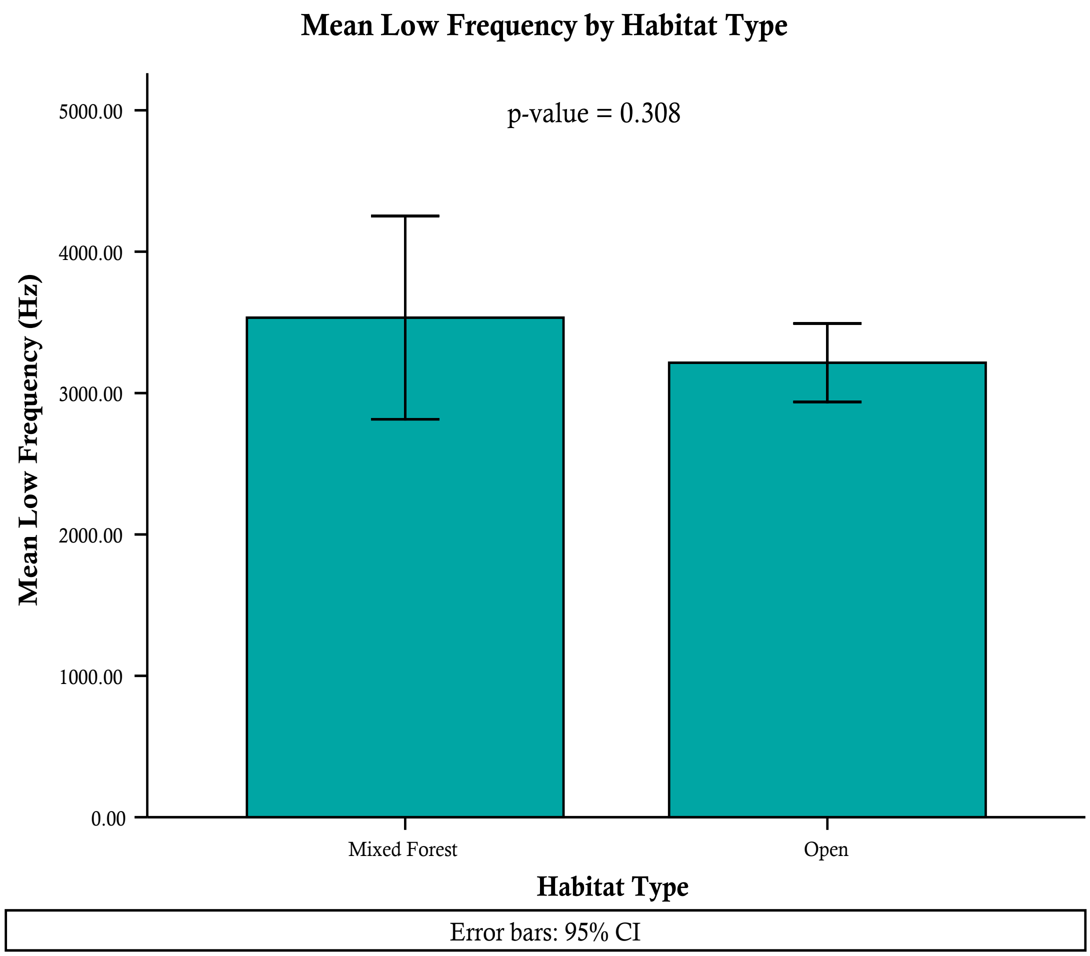
Open
Habitat Type
Error bars: 95% CI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Mean Low Frequency (Hz)
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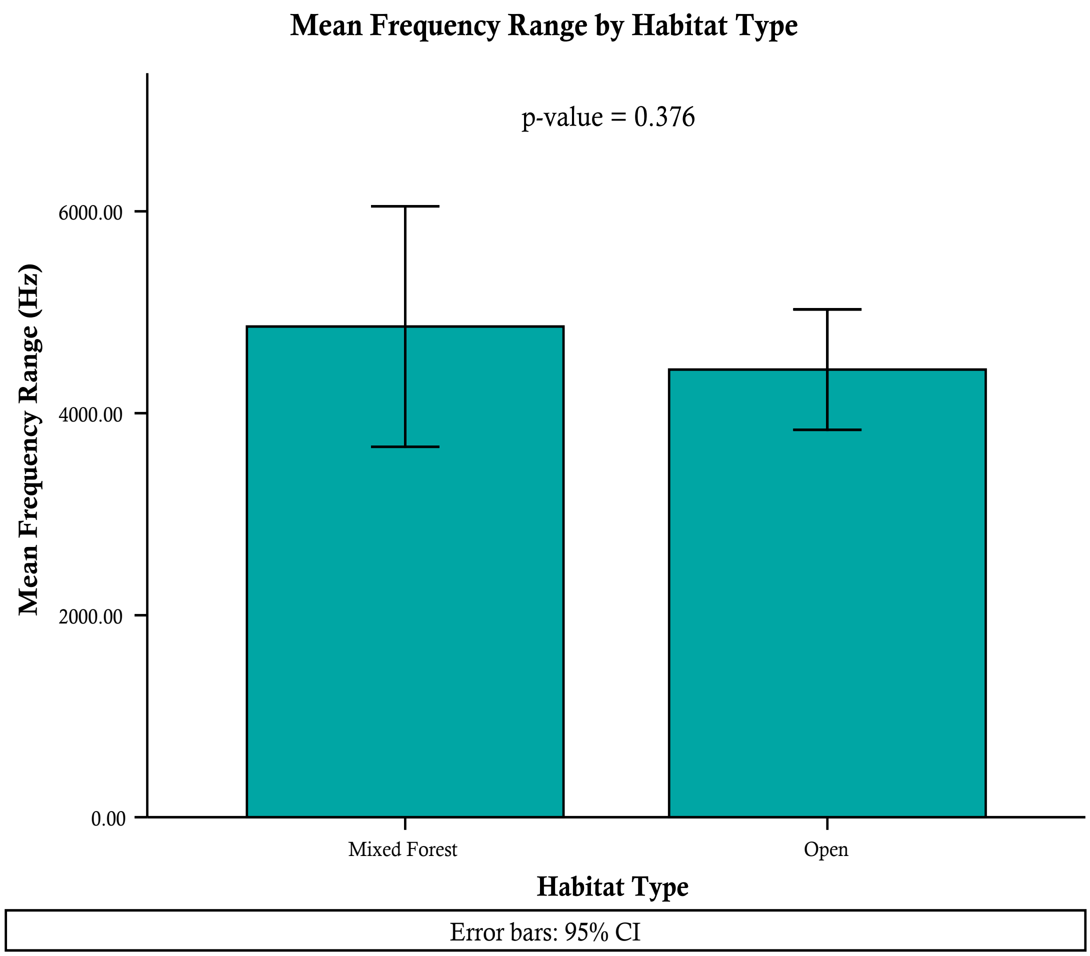
Open
Habitat Type
Error bars: 95% CI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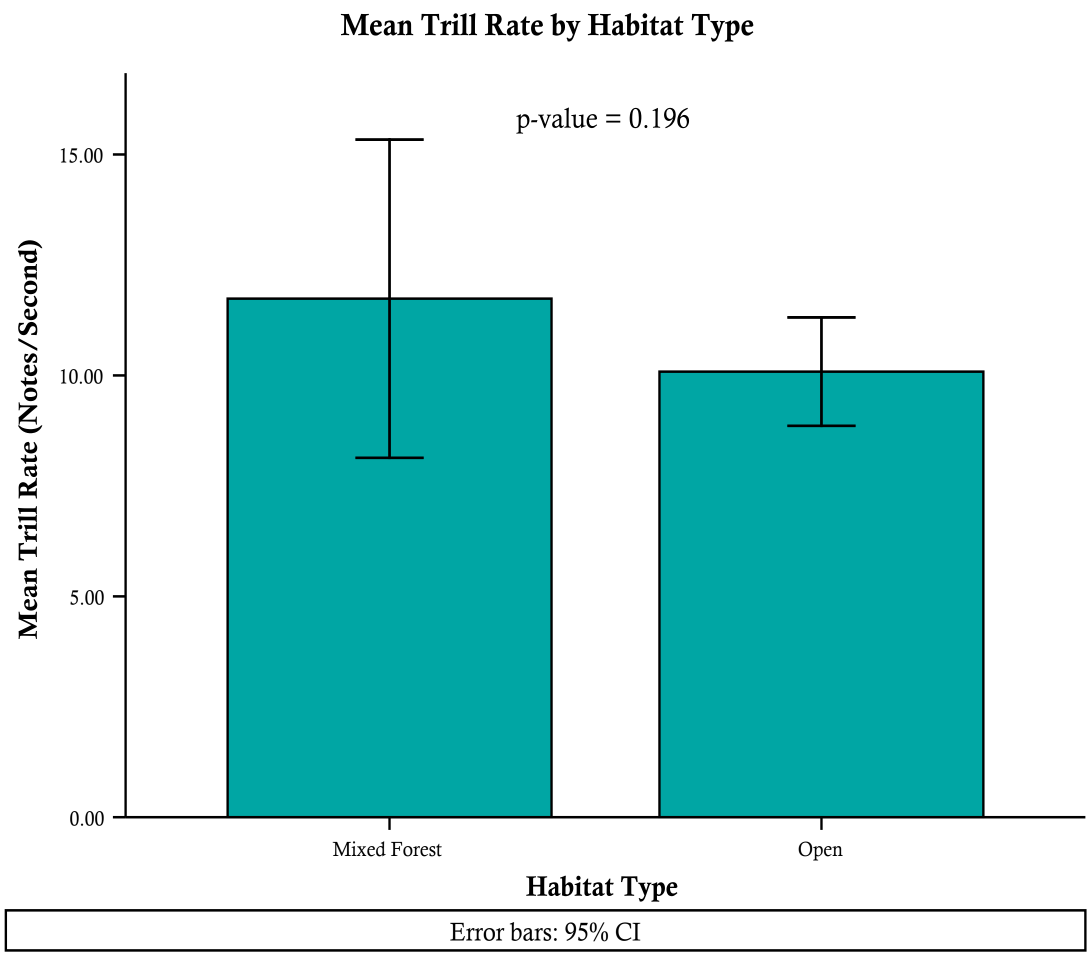
Open
Habitat Type
Error bars: 95% CI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Mean Trill Rate (Notes/Second)
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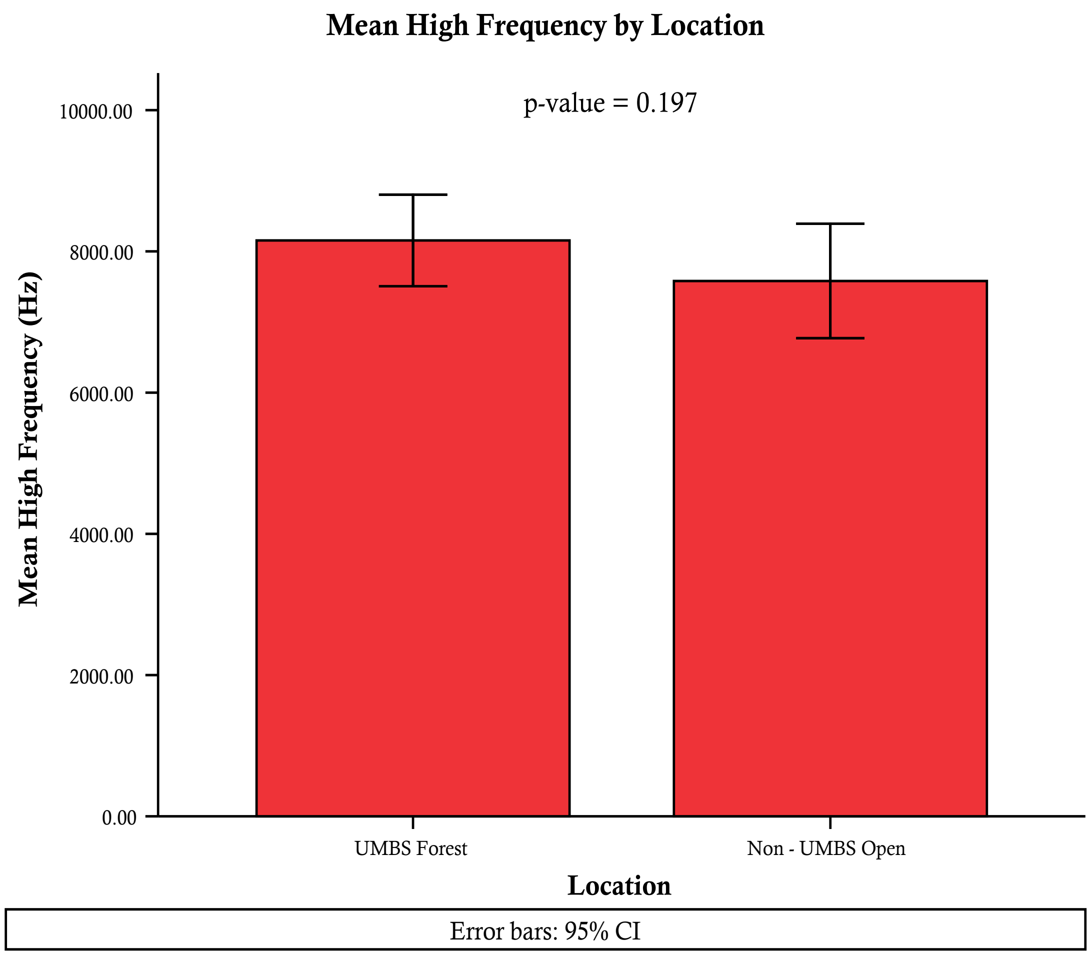
10.00
5.00
0.00
Mixed Forest
Open
Habitat Type
Error bars: 95% CI


Mean High Frequency by Location
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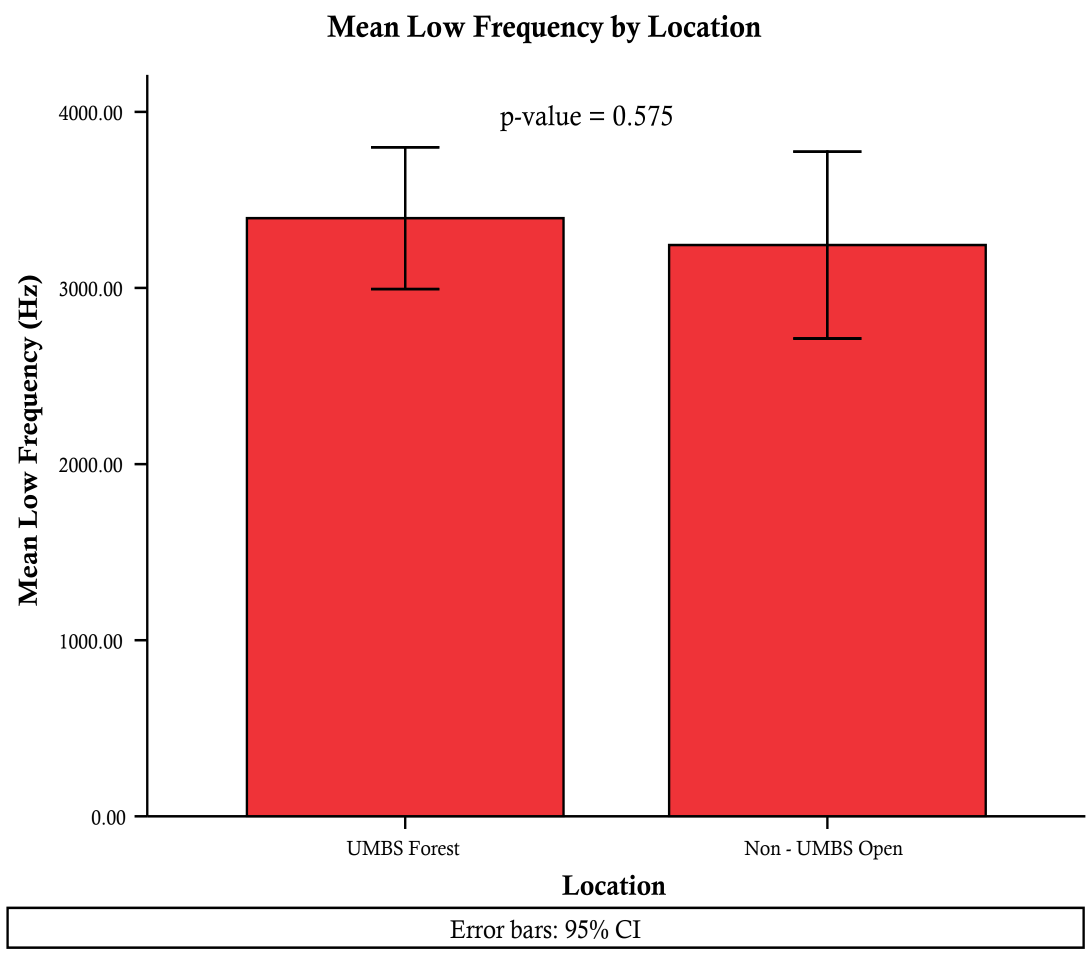
Mean High Frequency (Hz)
UMBS Forest
Non - UMBS Open
Location
Error bars: 95% CI


Mean Low Frequency by Location
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Mean Low Frequency (Hz)
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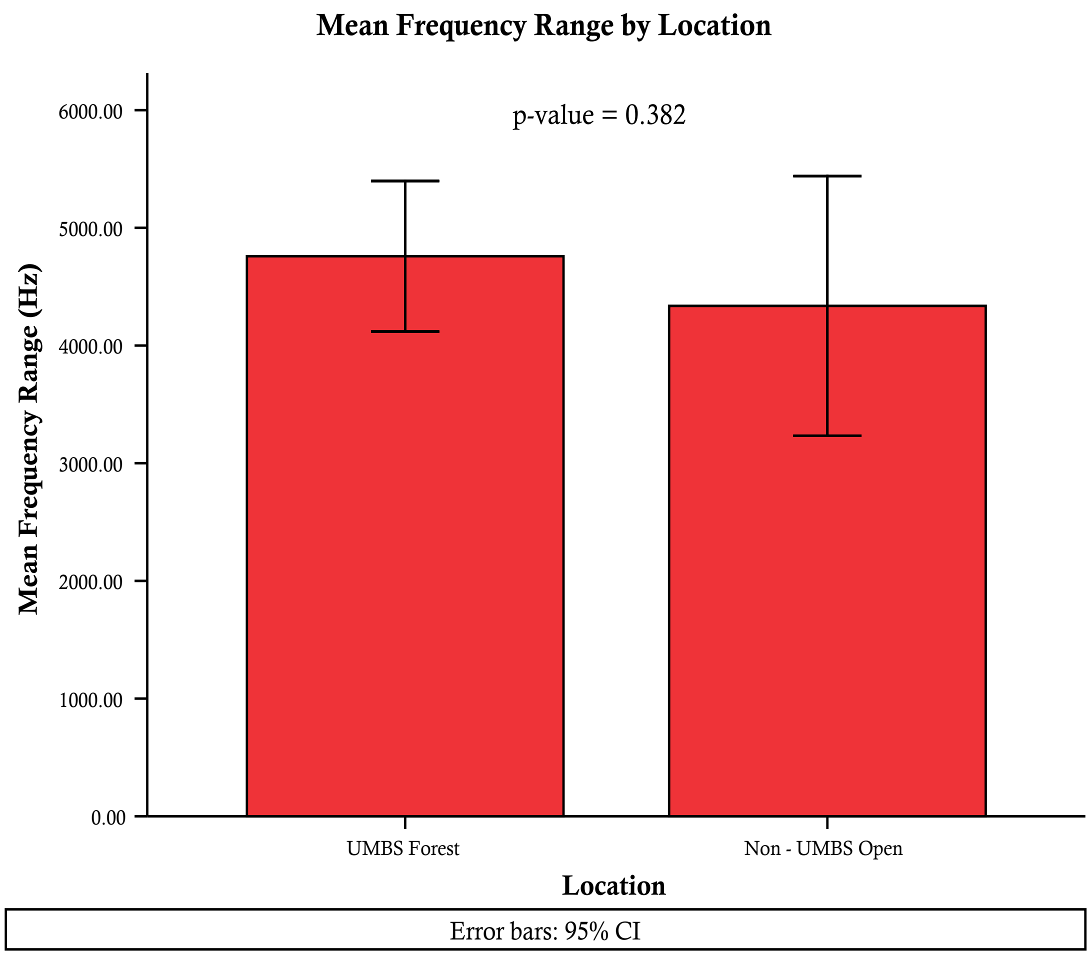
Non - UMBS Open
Location
Error bars: 95% CI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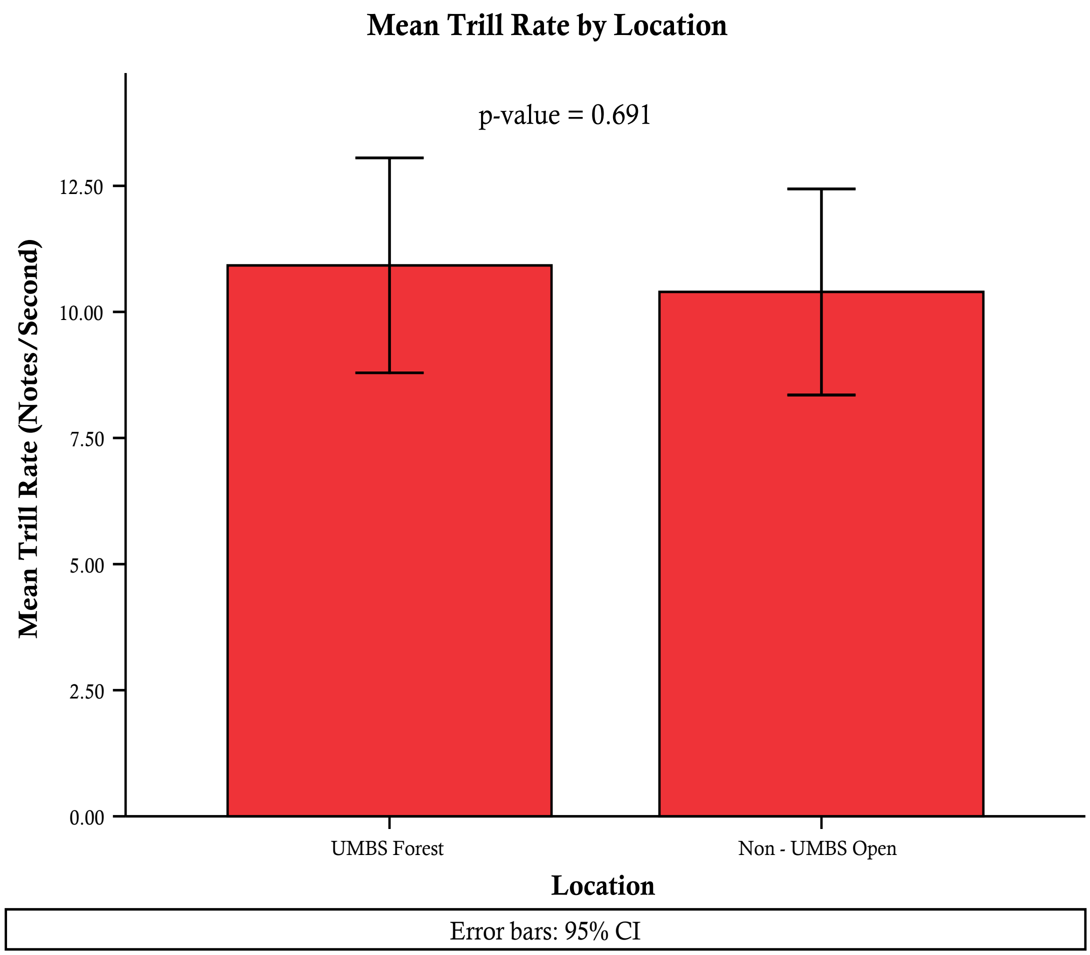
UMBS Forest
Non - UMBS Open
Location
Error bars: 95% CI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7.50
5.00
2.50
0.00
Mean Trill Rate (Notes/Second)
UMBS Forest
Non - UMBS Open
Location
Error bars: 95% CI